4.—*PALAEMONETES AUSTRALIS* DAKIN IN SOUTH-WESTERN AUSTRALIA.

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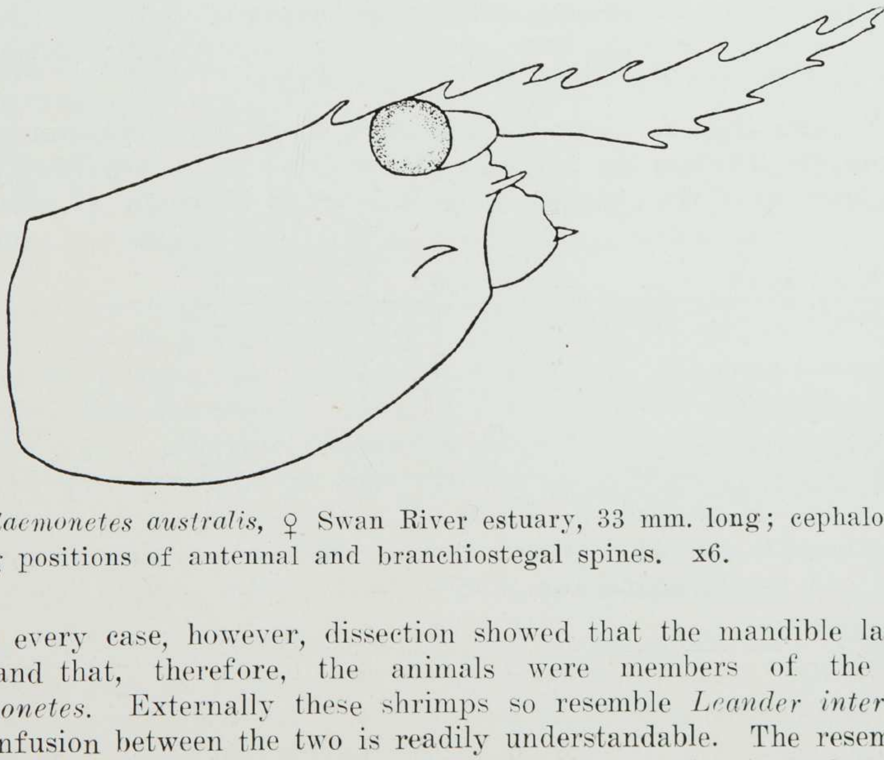
Read 10th August, 1937. Published 6th April, 1938.

Recently I had occasion to examine a collection of Palaemonid shrimps from the estuaries, brackish lakes and freshwater swamps at Two People Bay, near Albany, with the endeavour of determining how far the fresh-water *Palaemonetes australis* Dakin ranged into brackish-water, and, on the other hand, to what extent the marine *Leander* forms intruded into fresh-water. I was not a little surprised to find out that all of the specimens I had before me belonged to one species, and that *Palaemonetes australis*, which has hitherto been regarded as exclusively fresh-water, flourished not only in the brackish lakes on the plain near Albany but was the species to which the excessively abundant shrimps of the estuaries belonged.

Estuarine, river, lake and swamp shrimps were thereupon examined from as many localities in South-Western Australia as possible, including the collections of the Western Australian Museum, and confirmation was obtained of the fact that only one species was represented in all these varied environ-ments. This was the case also in the estuary of the Swan River, where the salt- and brackish-water shrimps had long gone under the name, locally, of *Leander intermedius* Stimpson.



Palaemonetes australis, ♀ Swan River estuary, 33 mm. long; cephalo-thorax showing positions of antennal and branchiostegal spines. x6.

In every case, however, dissection showed that the mandible lacked a palp and that, therefore, the animals were members of the genus *Palaemonetes*. Externally these shrimps so resemble *Leander intermedius* that confusion between the two is readily understandable. The resemblance extends to the position of the branchiostegal spine, which in both forms is set far back from the edge of the carapace and does not overlap its front edge. Prof. W. J. Dakin in his description of the species (1915, p. 571) did not discuss the position of the spine, which at the time he wrote was not considered as variable in this genus. Later S. Kemp (1925, p. 318) described *Palaemonetes hornelli* from South India, which he thought was probably unique in the genus in possessing a branchiostegal spine which was set far back from the carapace margin. As has been stated, *Palaemonetes australis* also proves to possess this character and hence its position in Kemp's artificial key to the genus (*l.c.*, p. 315) is incorrect. The species is otherwise quite distinct from *P. hornelli* and differs from it, for instance, in the smaller number of dorsal teeth on the rostrum, the proportions of the fused and free portions of the outer antennular flagellum and the proportionate lengths of the segments of the second leg. *Palaemonetes australis* also differs in lacking an appendix interna on the first pleopod of the male, conforming in this respect with all the members of the genus other than *P. hornelli*.

The following details of the structure and habits of *Palaemonetes australis* supplement Dakin's account, whose diagnosis covers, in general, the typical features of the species.

Colour.—The animal is translucent, with a slight brownish green tinge. Minute chestnut-brown chromatophores, centred with black, are scattered uniformly over the whole body, including the eye-stalks, peduncles of the antennule and antenna, the squame, rostrum and legs. The spots are aggregated into more distinct lines transversely on each abdominal sclerite near its posterior margin, excepting the last two and the telson. On the rostrum occur two longitudinal, sub-marginal rows of pigment spots, and on the carapace there run one longitudinal and one oblique line of spots, with transverse "offsets." The chela of the second leg has no distinctive colour, such as affords a useful diganostic feature in discriminating between species of the allied genus *Leander*.

Variation in Rostral Teeth.—As with the European *Palaemonetes varians* (Leach) there is considerable variation in the number of teeth on the rostrum, and also, as in that species, there seems to be no correlation between the number of teeth and the nature of the environment.

Specimens from the Swan River estuary (marine conditions in summer, diluted in winter) show the following rostral formula (the small tooth forming the bifid tip of the rostrum being included in the count of the dorsal teeth) :—

Dorsal teeth	5	6	7	8	9
Number of Specimens	1	1	18	5	2

Ventral teeth	2	3	4
Number of specimens	2	21	4

Combinations	7/3	8/3	7/4	9/3	6/3	9/4	8/4	5/3	8/2
Number of Specimens	15	3	2	1	1	1	1	1	1

Specimens from King Creek Lagoon (salt) near Two People Bay, Albany, had the following formula :—

Dorsal teeth	5	6	7	8	9
Specimens	2	14	3	0	0

Ventral teeth	2	3	4
Specimens	0	18	1

Combinations	6/3	7/3	5/3	7/4
Specimens	14	2	2	1

Shenton Park Lake, Subiaco, specimens (fresh-water) showed the following variations:—

Dorsal teeth	5	6	7	8	9	
Specimens	1	9	13	1	0	
Ventral teeth	2	3	4			
Specimens	0	16	8			
Combinations	7/3	6/3	7/4	6/4	8/3	5/3
Specimens	7	7	6	2	1	1

Lake Seppings, Albany (fresh-water):—

Dorsal teeth	5	6	7	8	9
Specimens	0	3	3	0	0
Ventral teeth	2	3	4		
Specimens	1	6	0		
Combinations	6/3	7/3	7/2		
Specimens	3	2	1		

Canning River at Gosnells (fresh-water):—

Dorsal teeth	5	6	7	8	9
Specimens	0	1	6	1	0
Ventral teeth	2	3	4	5	
Specimens	0	4	3	1	
Combinations	7/3	7/4	7/5	8/4	6/3
Specimens	3	2	1	1	1

Several specimens from all localities lacked the bifid extremity to the rostrum, while in other cases a supplementary small tooth formed a trifid tip. An abnormal specimen from the Canning River, Gosnells, showed the formula of 10/5, a fracture near the tip of the rostrum having resulted in regeneration of the extremity with additional teeth.

These formulae tend to show that rather a different average prevails in different areas, supporting Gurney's view (1923, p. 115) in his review of the variation of the rostral teeth of *R. varians*, that a statistical study of the variations of the rostral teeth based on a large amount of material "would show constant local variations, since many populations of this species must be isolated for long periods and subject to intense selection."

Second Leg.—In the second leg the carpus is longer than the propod and the merus, but the proportions vary. The dactylus is 40-45% of the total length of the propod, the chela being quite slender. The merus is generally slightly less than the propod in length, though in some cases these two segments are equal. All individuals differ in the proportionate lengths of the second leg segments from the otherwise externally closely similar *Leander intermedius*. In the latter species the propod exceeds the carpus in length, the merus is considerably shorter than the propod and the dactylus is 50% of the length of the propod. (See table.)

Outer Antennular Flagellum.—The free portion of the outer antennular flagellum varies from equality with the fused portion to being twice its length, and this variation seems to have no correlation with environment or sex. Many Swan River estuary specimens have the free portion of the same length as the fused part, which is the condition which Dakin describes from his type material from the Avon River at Northam.

The following table gives the proportions, in a number of individuals from various localities, of the lengths of the second leg segments and the ratios of the parts of the outer antennular flagellum. The measurements are expressed as percentages of the carpus and the fused part of the flagellum, respectively.

	Length.	Second Leg.				Outer antennular Flagellum.	
		Dactylus.	Propod.	Carpus.	Merus.	Fused part.	Free part.
		Leander intermedius.					
	mm.						
Garden Is.	34	60	123	100	88	100	226
Do.	35	56	118	100	78	...	...
		Palaemonetes australis.					
Swan River estuary ...	34	42	98	100	70	100	88
Do. do. ...	32	37	84	100	67	100	100
Do. do. ...	31	33	79	100	69	100	175
♂ Do. do. ...	33	48	89	100	69	100	137
♂ Lake Gardner, Two People Bay (Brackish)	27	34	78	100	75	100	214
♀ Do. do.	26	31	74	100	66	100	100
♀ Creek into Princess Royal Harbour (Salt)	30	26	70	100	66	100	139
Canning River, Gosnells (Fresh)	38	30	76	100	74	100	200
Monger's Lake (Fresh)	...	28	63	100	65	100	88
Do. do.	...	...	...	...	...	100	106

Differences between Brackish and Fresh-water Populations.—In *Palaemonetes varians* the brackish-water and fresh-water forms are regarded as being structurally indistinguishable, but physiological varieties have been described on differences in reproductive habit (differences in size of eggs laid and the stage of development on hatching). Gurney (*l.c.*, p. 122) has further found that fresh-water examples of the species from Tunisia differ from the brackish-water representatives in the inordinate length of the appendix masculina of the second pleopod of the male and also the ratio of the free part of the outer antennular flagellum to the fused part. In *Palaemonetes australis* the appendix masculina does not vary in length whatever the environment, being intermediate in length between the appendix interna and the endopodite. The other variable features cannot at present be correlated with environmental differences.

Distribution and Occurrence.—The genus *Palaemonetes,* though very widespread in its distribution, has been recorded from Australia only in the south-west corner, and here the species has been collected from Two People Bay on the south-east coast to the Gingin Brook, north of Perth. Within this area the animals occur in streams, from the fresh upstream reaches to their brackish-water mouths and estuaries, in many of the brackish-water lakes of the coastal plain which appear to be isolated marine basins (such as Lake

Clifton and the lakes near Two People Bay), and entirely fresh-water lakes and swamps. As far as the estuarine and lacustrine distribution is concerned this is closely paralleled by the Goby, *Glossogobius suppositus* Sauv. (syn. *G. vomer* Whitley, *Rec. Austr. Mus.*, vol. xvii., 1929, p. 135). Neither *palaemon* nor *Atyid* shrimps occur in South-Western Australia, whose place in the fresh-waters is taken by *Palaemonetes australis*.

In the Swan River estuary *Palaemonetes australis* is very abundant throughout, but in the harbour at Fremantle it is replaced by the marine form, *Leander serenus* (Heller), which is the common shore form around the South-West. *Leander intermedius* has not thus far been taken in the estuary but has been dredged in Cockburn Sound.

Experiments on varying the Salt Concentration of the Outer Medium.—The distribution of *Palaemonetes australis* as indicated is evidence that the species is a euryhaline animal with a wide degree of tolerance of the salt concentration of the medium in which it lives. In the Swan River estuary the animals are able to withstand very great fluctuations of the salinity during the year. In the summer and autumn and early winter the animals live in undiluted sea-water, and in the late winter and spring the flood waters come down and the fresh water extends to a depth of six or eight feet with brackish-water beneath, and the shrimps continue to live at all levels. There are very slight changes in the main estuary due to the tide, as the daily rise and fall is about eighteen inches or so, and this is quite overshadowed by the effects of the winds. Therefore the violent daily fluctuations in salinity, which are the order in European estuaries for instance, have no counterpart in local waters. The seasonal variations in salinity are relatively gradual and the osmo-regulatory equipment of *Palaemonetes* is evidently adequate to accommodate itself to them.

Experiments made to test the reactions of the animals to fluctuations of salinity showed, however, that *rapid* alterations of the concentration of salts, over a wide range, broke down the osmo-regulatory mechanism of the animals, and they succumbed. Gradual, but not unduly slow, alterations of the medium succeeded in transferring brackish-living shrimps quite safely to fresh-water and vice versa. Details of some of these experiments follow.

1. On May 14, 1936, 11 specimens brought from Monger's Lake (fresh) were placed suddenly (after the temperatures had evened) into undiluted water from the Swan River estuary (Chlorine, 19.8 per mille). Next day though only two were dead, all the survivors were very lethargic and had acquired an opaque whitish appearance. They never recovered; one or two died each succeeding day and the last survived to May, 26.

2. On the same day 15 specimens from Shenton Park Lake, Subiaco, (fresh) were placed in diluted estuary water (Chlorine 12.3 per mille). These remained normally active and transparent. Four days afterwards they were further transferred to undiluted estuary water (Chlorine, 19.8 per mille) but the transition proved too severe and the animals became sluggish and opaque, five dying within 24 hours, and the others succumbed one by one until none was left 15 days later. Never during this period did the lingering survivors show normal activity.

3. A third lot of specimens and two *Glossogobius suppositus* from the Swan River upper estuary at Guildford (Chlorine, 10.7 per mille) were

placed in fresh-water. The animals remained very active and transparent. One shrimp which survived a mishap in the aquarium, and the two gobies, were transferred a fortnight later into estuary water from Crawley (Chlorine, 18 per mille). All the animals were quite unaffected and the shrimp successfully underwent ecdysis.

4. A collection from the Swan River at Crawley (Chlorine, 18.55 per mille) was put into fresh water, but all died overnight, with the bodies greatly swollen. What probably happened, as in all these cases, was that the osmo-regulatory control had broken down under the strain of the too great change in the concentration of the outer medium, and water diffused into the body unimpeded, causing distension of the tissues and death. This experiment was performed at the same time as No. 3 and the contrast of the respective effects was striking.

5. An endeavour was now made to effect the transition from salt-water to fresh more gradually. On May 28 a catch of sixty shrimps was taken from the Swan River estuary (Chlorine, 18.55 per mille) and each day (with a few exceptions) the water was diluted. The following were the results:—

May 29—all active; the water was then diluted to Chlorine, 17.55 per mille.

May 30—all active; water was diluted to Chlorine, 10.85.

June 1—all active; water was diluted to Chlorine, 8.2; 5 hours later though all the animals remained alive they had become sluggish.

June 2—25 were found dead, being swollen and opaque, the remainder were active and transparent; the water was then diluted to Chlorine, 7.3.

June 4—all alive and active.

June 5—ditto; water diluted further to Chlorine, 4.03.

June 6—all active. The specimens were now divided into two lots; one (A) consisting of 21 animals, was placed into fresh-water and the medium of the other (B) including 15 shrimps, was diluted to Chlorine, 3.38 per mille.

June 7—In A, 6 shrimps were dead, the remainder sluggish and not so active as usual though still transparent. In B the animals remained normally active and the water was further diluted to Chlorine, 2.60.

June 8—In A some shrimps resumed activity, other remained sluggish but there were no deaths. The animals in B continued normal and the water was diluted to Chlorine, 1.54.

June 9—In A animals alive but quiet; in B normal, water diluted to Chlorine, 1.01.

June 10—In A animals alive but quiet. In B normal; water diluted to Chlorine, 0.73.

June 11—In A 2 dead, others quiet. In B normal; water diluted to Chlorine, 0.38.

Palaemonetes in aquaria is very sensitive to the slightest contamination and it is the first animal to register discomfort when anything is wrong by attempting to leap out of the vessel.

Breeding Period.—Dakin considered that the breeding season coincided with the early months of the summer. The earliest time I have found ovigerous females was towards the end of August and the latest in January, no breeding taking place in the late summer or autumn. The breeding season seems identical in fresh-water and estuarine environments. It is interesting to note that in the Swan River estuary the effects of the winter flooding are near their maximum in August, yet this rigorous period has no effect, apparently, on the breeding.

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